

## SHOULDER- AND NECK HOLDER

## CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of co-pending international application number

5 PCT/DE98/03271 (WO 99/24292, EP 1 037 771 B1, DE 197 58 498 C2) filed Nov. 10, 1998 and claiming the priority of DE 197 58 498 A1 filed Nov. 11, 1997 is revised and refiled.

## 1. Field of the Invention:

10 The present invention relates generally to a shoulder- and neck holder to additionally restrain the shoulders and neck of a passenger, restrained by a seat belt, in order to dampen vibrations and substantially reduce the acceleration-depending loads below the injury-related values

- in the event of arbitrary accident of a vehicle, train or an aeroplane or
- during turbulence-related vibrations of an aeroplane.

## 15 2. Discussion of the Related Art:

It is known in the prior art to provide

- a three-point seat belt (safety belt or lap-shoulder seat belt) consisting of a shoulder belt extending across the torso and of a lap belt extending across the lower part of body in motor vehicle;
- a two-point seat belt acting as lap belt extending across the lower part of body in an aeroplane or a rear seat of vehicle or
- a substitute for a seat belt to restrain the shoulders and neck.

20 In order to formulate in single terminology a generalized definition for the proper term is presented:

25 "belt portions 1.1, 1.2, 1.3 and 1.4" for members of a multi-point seat belt 1a to 1d (Figs. 1, 14) ref. to EP 1 037 773 B1 (WO 99/24294, PCT/DE98/03270, DE 197 49 780 C2). The upper part of body is restrained by extending the shoulder belt portions 1.1, 1.2 crosswise in an „X-shape" while the lower part of body is restrained by the lap belt portion 1.3.

30 "belt portions 1.2, 1.3 and 1.4" for members of a three-point belt 1e to restrain the upper part of body and to restrain the lower part of body, shown in Fig. 14;

"belt portion 1.3" for conventional two-point or lap seat belt;

"floor 6" for vehicle-, train- or aeroplane floor (Fig. 14);

"seat frame" for frame of seat backrest or seat-cushion;

35 "accident" of a vehicle, train or aeroplane for front-, side-, rear collision of a vehicle or pile up (mass accident) or for train-, aeroplane accident or turbulence-related vibrations of an aeroplane;

"energy-absorption" for absorption and release of impact energy as well as dampening vibrations;

40 "undampened energy-absorption" for absorption and release of impact energy while vibrations are undampened;

"energy-absorbing method" for gradually absorbing subenergies  $\Delta F_i$ , the addition of which is equal to total energy  $F_n$  or belt force (Fig. 9) and the increment  $i$  of which increases from 1 to  $n$ , below the respective injury-related values by undampened energy-absorption, energy-absorption, preserving the clamping and friction forces of control-clamping elements associated with the fracture of the sites of predetermined fracture of clamping elements and energy absorbers during the energy-absorption, thus enhancing the survival chance and ensuring the restraint below the tensile strength of seat belt.

5 It is well known to restrain passengers, particularly, of vehicles with seat belts in the event of accident, where a small forward motion of the upper part of body at low speed is acceptable. However, in the crash tests at speed of 55 km/h the rotating masses of torso 95.2 and head 95.1 are thrown forward and twisted by the acceleration-dependant loads [1, 2, 6 to 8].

10 Due to lack of restraint systems in trains passengers are not restrained, thus subjected to severe or fatal injury when ejected from the seats in accidents.

15 It is well known to restrain passengers of aeroplanes by two-point or lap seat belts, which are incapable of restraining the upper part of body as well as head in accidents, particularly associated with sudden turbulence. Consequently, severe/fatal injuries have been reported and, for sure, will be reported in the future.

20 According to US 2,833,554, US 3,392,989, US 3,713,694, US 3,829,158, US 3,901,550 (DE-OS 24 28 285), US 4,700,632, US 5,529,382, DE-OS 2152146 and EP 0003354 A1 (DE-OS 2803574) a restraint device, substituted for a seat belt (restraint system), restrains the shoulders, lap and/or abdomen of a passenger. This feature is in contradiction to the law, valid world-wide, enforcing the use of seat belts during travel. Unbelted passengers are not 25 tolerated. Police fines them for belt violations. Recently, in Washington State a hefty \$ 86 fine per passenger, imposed therefor, is legislated. Furthermore, Administrations world-wide would reject motor vehicles, equipped with such restraint devices, thus putting the car manufacturer out of business.

30 Moreover, all the restraint devices need space, the design is bulky and unattractive. By no means can child-seats and/or baby cots be installed in the car. The overall stylish impression of the vehicle is not beneficial to sales. When cleaning, repairing or stepping in or out of the vehicle body, the passengers, in particular, children can stumble over such devices, unintentionally hit them and/or be obstructed, for example, by the seat harnesses, located in the resting position at the head level, ref. to US 3,392,989. Evidently, all the restraint devices 35 are incapable of absorbing great energy, dampening strong vibrations, ensuring the restraint of the passengers in any real-world accident, for example, submarining, rollover, multi-crash etc. As a result, passengers are exposed to the danger of being severely/fatally injured and/or burnt alive if the car catches fire.

40 According to US 3,901,550, that has the best feature among the above-mentioned restraint devices, the passenger is secured by the restraint of both shoulders and the pelvis 96 by means of two pairs of air-cushioned guard arms 16 and 18. The following problem cases cast doubt on the survival chance and applicability:

- 45 I. Due to the gap  $s_i$  between the shoulders and shoulder cap the shoulders and head 95.1 can oscillate. High injury severity results from
  1. large acceleration of head of a belted dummy about 83 g in the crash test of a vehicle without airbag [1],
  2. limited energy-absorption property of the air chambers to dissipate large energy of the upper part of body of belted dummy, thrown forward, by a force of about 64 g and

3. lack of neck cap to dissipate large energy of the head, yaw-accelerated at the yaw angle  $O$  [2], acting as the second rotating mass.

A passenger, submarining (slipping downward) in a rear collision, releases himself from the restraint by the guard arms 16 and 18, thus exposed to severe/fatal injury.

5 In a real-world accident, the load cases of which are illustrated in Figs. 1 and 2, the survival chance is low due to lack of energy- and shock absorber.

10 II. Upper part of body, defined by various outer contour from SC1" to „SC3" ,for example, upon putting a thick winter coat, can't be retained because only one outer contour „SC2" is configured when pulling together the air chambers 26 of guard arms 16 via a tension strap 30. The outer contour is determined by two body shapes (both shoulders and chest) and the passenger, whose circumference varies depending on the clothes worn.

III. The manufacturing costs for two pairs of guard arms and two feeding systems are higher than that of the shoulder- and neck holder including the seat belt.

IV. Passengers are severely/fatally injured in the event of submarining or rolling over.

15 According to DE 37 06 394 C1 a backrest of a front vehicle seat is equipped with deformation elements, which are deformed beyond the yield limit for the purpose of undampened energy-absorption when

- a passenger, seated in the front, is thrown against the seat backrest in a rear collision or
- an unbelted passenger, seated in the back, is thrown against the seat backrest in a front collision.

20 The supporting members of the seat backrest frame serve as deformation elements, to which expanding and contracting elements are arranged, the geometry of which and elastic limit of which vary along the length of the seat backrest.

25 Ref. to DE 42 38 549 A1 thin walls of a seat backrest frame are proposed for undampened energy-absorption.

30 According to DE 92 02 219 U1 a belt retractor, equipped with a clamping device, acts as delimiter of a restraint system in conjunction with deformation and energy-absorption. The belt retractor and clamping device are connected to each other by a plate with ribs. Due to clamping of the belt in excess of a threshold value the ribs are deformed, thus increasing the distance of the clamping device from the belt retractor. The energy, imposed on the belted passenger, is released by the fracture of predetermined sites of the ribs.

35 A seat ref. to EP 04234348 A1 is proposed for survival chance in a mid-front collision of car, train or aeroplane. A pair of energy absorbers is pivotally attached to a pair of front and rear seat legs, which are pivotally attached to the floor 6 and a seat-cushion frame. Each energy absorber consists of a rod, pivotally attached to the rear seat leg and floor 6 and having a cone-shaped end, and a tube, pivotally attached to the front seat leg and seat-cushion frame and having a cone-shaped collar to receive the end of the rod. During the movement of the seat in mid-front collision, the end of the rod expands (reams) the tube, thus performing work of deformation and friction in order to dissipate energy. For the purpose of gliding the end of the rod along the inner cylinder of the tube, the wall may not be cracked, but only deformed.

40 Exemplified by DE 39 33 721 A1, another energy-absorbing friction device, mounted to a vehicle part, has a tube, which is deformed by the belt force. The end of a rod, protruding through the tube, is connected to the seat belt and several barrels of a role (bearing balls) are arranged around the other end, inserted in the inner cylinder of tube. The outer diameter of the rod and barrels of a role is a little larger than the inner diameter of tube. Under the load of belt force the barrels expand the inner cylinder of tube.

A very low work of deformation and friction is achieved, nevertheless, this invention contains the first-promising feature which only in co-operation with the seat belt is able to effectively absorb energy.

5 US 5,544,918 discloses an energy-absorbing management device, which comprises a crushable (deformable) honeycomb to absorb energy and a controller consisting of three-sensor mechanisms to monitor and sense the weight of the passenger, his forward motion and the severity of the vehicle collision. Unfortunately, sensors are incapable of evaluating crash data within few milliseconds and responsible for false deployment of airbags, resulting in decapitations, severe/fatal injuries and burns, which are reported in [6 to 8] and EP 0844939  
10 B1. Due to the unreliable operation of sensors car manufacturer has no choice to start recall program, which impairs the reputation and is costly.  
A more reliable and far cheaper energy-absorbing device is described hereinafter and in DE 197 58 497 C2.

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## SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to restrain both shoulders and the neck of a belted passenger, absorb energy and dampen vibrations in order to avoid whiplash [8] and minimize the loads  $F_{Sy}$ ,  $F_{Hy}$ ,  $F_{Sx}$ ,  $F_{Ix}$  and/or  $F_{Sz}$  below the injury-relevant threshold values in the event of a real-world accident, shown in Fig. 1.

20 This principle and other objects of the present invention are accomplished by the following features (proposals):  
25

- user-friendly device to ease the restraint of both shoulders and the neck and
- integration of the shoulder- and neck holder, equipped with energy absorbers, sets of vibration-dampening energy absorbers, a seat 3a to 3e and a conventional seat belt 1e or a multi-point seat belt 1, 1a to 1d into an energy-absorbing, vibration-dampening safety seat, such as a safety baby-cot 86, safety child-seat 85a, 85b or safety adult-seat 85a to 85e, illustrated in Figs. 1 and 14,

in order to prevent head impacts with aeroplane interiors [4, 5] as well as vehicle interiors such as steering wheel [6], window pane [7], avoid whiplash [8], dampen vibrations and 30 control all acceleration rates and loads below the respective injury-related values during any real-world accident, thus ensuring the restraint function and saving life.

Summary of the advantages of the present invention in real-world accidents:

- In compliance with the law, valid world-wide, enforcing the use of seat belts by the use of the conventional or newest seat belt ref. to WO 99/24294, the restraint of shoulders and/or neck by the shoulder- and/or neck holder can be determined before the travel/flight or in accident/turbulence or in excess of a threshold speed e.g. over 80 km/h. The deflecting point or end of a conventional seat belt 3e (Fig. 14) is located at the top edge of seat backrest. The compound of two restraint systems 1c / 10, 1a / 10a, 1b / 10b, 1d / 10d, 1e / 10e minimizes movements/motions/torsions and all acceleration-dependant loads (Fig. 1), imposed on shoulders, neck, torso, the lower part of body and, in particular, head acting as the 2nd mass.
- The upper part 95 of body consists of torso 95.2 and head 95.1. In the z-y and x-y plane (Fig. 1) the pitch- and yaw angle  $U_S$  and  $O$  of the 1st mass of torso about the rotating „S“- and z-axes converge toward zero owing to the restraint of shoulders of the belted torso, thus reducing the forward motion, pitch acceleration  $\ddot{U}_S$ -,  $\ddot{U}_H$ - and yaw acceleration  $\ddot{O}$ -dependent force  $F_{Sy}$ ,  $F_{Ily}$  and  $T$  in arbitrary front collision.

Analogously, the forces  $T$ ,  $F_{Sx}$ ,  $F_{Ix}$  and/or  $F_{Sz}$  are reduced in arbitrary side collision and/or rollover. This feature contributes to new development to increase the reliability of substitutes for airbags. Due to the unreliability and false deployment of airbags newspapers [3] have reported recall programs, decapitations, severe/fatal injuries, burns etc.

5    - Beyond doubt, one-piece neck cap 10.4a, 10.4c, rigidly connected to shoulder cap 10.2a, 10.2c, sustains the neck e.g. of a cervical trauma suffering passenger at the best. If such shoulder- and neck holders 10a, 10c were installed in a vehicle or an aeroplane, healthy passengers would reject to use them when it is hot or the passenger is wearing tie or jewellery around her/his neck. This controversy is resolved by the features of one the  
10      Claims 1 to 4.

10    - By making the caps 10.2, 10.2a to 10.2f and a number of the respective alternate energy absorbers 10.3, 10.3a even a passenger with broad shoulders can use the holder by changing shoulder caps.

15      Moreover, the overall stylish impression of seats is spoilt by shoulder- and/or neck-shaped caps, when not in use, thus impairing the sales. Understandably, the design of caps of  
15      holders e.g. 10, 10b (Fig. 14) for expensive luxury cars depends, principally, on the form of the seat 3c, 3b. To protect the broad shouldered passenger the shoulder caps must be changed. The decision for shoulder- or seat -shaped caps depends on the purpose of  
20      holders installed in the motor vehicle (bus, ambulance, van, luxury car etc.), train and aeroplane. This controversy is resolved by the features of one the Claims 16 to 20.

20    - The problem case II, aforementioned, is resolved by variable restraint of a single body member comprising the shoulders and neck. Preferably, one- or two-piece, shoulder-shaped energy absorbers 10.3, 10.3a can be detached from one- or two-piece, deformable caps 10.2, 10.2a to 10.2f and one- or two-piece, neck-shaped energy absorbers 10.5,  
25      10.5a, 10.5c from one- or two-piece, deformable caps 10.4, 10.4a to 10.4c, 10.4f as well as fastened thereto via adhesive fastener such as zip-, snap-in- or Velcro fastener. The absorber as well as cap can be made of one- or two pieces.

30      For the purpose of cost saving associated with the demand for passengers, with different neck- and shoulder shapes, a large number of neck- and shoulder-shaped energy absorbers  
30      10.3, 10.3a, 10.5, 10.5a, 10.5c and a low number of caps are produced. Fig. 14  
35      exemplifies the adaptation of the holder to the body proportion of a child, sitting on the seat 3a, 3b, by using detachable holder 10a, 10b.

35    - For the purpose of quick storage and removal, the holder 10a to 10c is inserted into the seat backrest or -cushion of seat 3a to 3c (Fig. 14), secured by inserting the pair of latch plates 10.1, 10.1b, 10.1f therein and released by pressing the release button 87a to 87c. Both latch plates of shoulder- and neck holder 10a are disengaged from seat cushion 3.1a (Fig. 14) by pressing the release button 87a. As front portion of that seat cushion the holder 10a is removed from the cutaway portion (opening) to exploit its space for accommodation of both lower legs of a child sitting on the rear portion thereof.

40    - For the convenience of the passenger and in cases of quick-rescue and emergency a master release button 84 of lap buckle assembly 9.1 is pressed to release all latch plates of the seat belt from the respective buckle assemblies and  
40      \* to move the holder 10d, 10e back from the operative position to the resting position or  
45      \* to release all latch plates of holder 10, 10a to 10c, 10f from the respective buckle assemblies.

45    - Both casings 29a of rotatable device 28a are guided by two pairs of inner tubes 71, 72 of seat backrest frame 3.4d, 3.4e and can be locked in the required height.

- Large impact energy is absorbed, during which vibration is damped, by
  - \* fracture of pads of predetermined fracture „S<sub>11</sub>“ to „S<sub>mn</sub>“ and „H<sub>11</sub>“ to „H<sub>nm</sub>“, which define the energy absorber 10.3, 10.3a and 10.5, 10.5a, 10.5c;
  - \* fracture of sites of predetermined fracture „s“ of spring 10.9;
- 5 \* fracture of sites of predetermined fracture of clamping elements of the following sets of energy absorbers 30, 40, 50 (Figs. 10 to 12) having control-wires 37, 47, 57, representing 40e, 40f having wires 47e, 47f, which are tautly, less tautly and/or loosely connected to holder 10e; and
- 10 \* friction of clamping elements 32.1 to 32.e, 42.1 to 42.e, 52.1 to 52.e, which move along the respective retaining elements 31, 41, 51.
- The shoulder- and/or neck cap can be inserted or rotatably attached to or in the seat backrest. Furthermore, it can be adapted to the body proportion of a passenger by a width- and height-adjustable mechanism of the holder.
- 15 The sets of energy absorbers and accommodation thereof in the frame of seat backrest and/or seat cushion account for a method of construction to save space, weight and costs and to increase stiffness. Furthermore, the energy-absorbing elements are made by extrusion, depth extrusion, casting, die casting or of spring plate or of spring steel. A preference for the embodiments is given to elements, having round profile, which are the cheapest and easiest to manufacture.
- 20 The costs and reject rate are lowered by a single tolerance (over- or undermeasure of a round profile), pre-tensioning (biasing) the clamping elements on or in the retaining element and pre-assembling all sets of energy absorbers, which are pre-loaded, for the delivery and final assembly to the frame of seat backrest and/or seat cushion.
- 25 The position of clamping elements e.g. 42, 42.1, ..., 42.n to each other can be adjusted by choosing the adjusting holes „L<sub>1</sub>“ to „L<sub>e</sub>“ and/or by clamping the brackets 37b1 on the wires.
- 30 Owing to the property of the great energy-absorption by small mass, lighter materials such as magnesium-, aluminium-extrusion, die casting of GD-MgA12 or alloys or carbon/glass fibre-reinforced plastics, used for skis, are recommended for the caps of the holder, latch plates and parts of the set of energy absorbers.
- Fracture of sites of predetermined fracture „s“ can be used as court-evidence for a passenger having belted in the accident.
- Retaining elements (Figs. 1, 10, 11), integrated into the frame of seat backrest and/or seat cushion, enormously increase the stiffness of seat. The buckle assemblies, receiving the latch plates, are sustained by the frame of seat backrest and/or seat cushion.
- 35 - Two- or three-point seat belt can be equipped with sets of energy absorbers. The guide pieces of buckle assemblies, plug-in connected to the respective latch plates, have two functions to integrate energy absorbers into the two-, three- or multi-point seat belt and to guide the movement of the buckle assemblies, when loaded or unloaded.
- 40 - Due to the increased tension on the wire the clamping element performs the work of deformation and friction, which is released in excess of threshold value resulting in fracture of sites of predetermined fracture „s“, two sites shown in Fig. 11, upon the contact with both heads of stop pin or bolt 46.1, ..., 46.n. The site of predetermined fracture can be formed as crack, corrugation, hole or recess.

- In another embodiment the performed work (energy) is released by fracture
  - \* in excess of the yield limit of the clamping element,
  - \* due to constrained deformation of carrier piece or expanding (reaming) the clamping element upon the contact with a wedge-shaped stop element 41.3 (Fig. 11) or with a wedge-shaped rib 41.1, 51.1 (Fig. 12).
- 5 – Generally, the energy absorber consists of a tube-shaped base body with/without rib, serving as retaining element, and at least one clamping element, which is arranged to or in the retaining element. Wires are employed to tautly, less tautly and/or loosely connect
  - \* clamping elements to each other, whereby a row of energy absorbers e.g. R42 (not denoted) is defined from the expanding clamping elements 42, 42.1 to 42.n and the retaining element 41 (Fig. 11). In similar manner the other rows of energy absorbers such as R32, R52 etc. can be built together;
  - \* rows of energy absorbers to define a set of energy absorbers 30, 40, 50 (Figs. 10 to 12) and
- 10 – \* sets of energy absorbers to couple member 1.2a, 1.2b of tie band (catch band) 1.1a, 1.1b, 1.5, 1.6, 47e, 47f (Figs. 1, 13a to 13c) to dissipate subenergies „ $\Delta F_i$ “ by applying the energy-absorbing method.
- 15 Injury-irrelevant threshold value is defined by the difference between two forces „ $\Delta F_i$ “, lower than the injury-related load. The threshold values may have different magnitudes.
- 20 For the energy-absorption up to the starting threshold value „ $\Delta F_1$ “, at least one clamping element 42e, 42f (Fig. 1) or energy absorber 10.3, 10.3a, 10.5, 10.5a, 10.5c is responsible. In order to prevent vibration and to fix the onset of energy-absorption at least one control-clamping element 52 must be biased up to an onset force-level e.g. „ $\Delta F_1 - 500 \text{ N}$ “, which is lower than „ $\Delta F_1$ “. Over this onset force-level the element, pulled by the corresponding wire 57, performs work of deformation and friction, during which the energy „ $\Delta F_1$ “ is released by fracture of sites of predetermined fracture of clamping element 42e, 42f, so that the passenger is neither injured nor thrown back. The energy increase about „ $\Delta F_2$ “ is compensated by the fracture of at least one complementary clamping element 52.1 to 52.n, so that the passenger is neither injured nor thrown back.
- 25
- 30 The gradual reduction of energy is repeated so long up to a load zone defined of „ $\Delta F_c - 500 \text{ N}$ “, in which all clamping elements are broken, the control-clamping elements 52 cannot move anymore and at least one control-clamping element 42, biased at „ $\Delta F_f - 500 \text{ N}$ “, and/or at least one clamping element of set of energy absorbers 40 perform(s) work of deformation and friction.
- 35 The energy increase about „ $\Delta F_f$ “ is compensated by the fracture of the control-clamping elements 52 and/or of at least one complementary clamping element 42.1 to 42.n, so that the passenger is neither injured nor thrown back. The gradual reduction of energy is repeated so long till
  - 1. the total energy „ $F_n$ “ is consumed or
  - 40 2. a new load zone defined of e.g. „ $\Delta F_h - 500 \text{ N}$ “, in which all clamping elements are broken, the control-clamping elements 42 can't move anymore and at least one of the following sets of energy absorbers decrease energy, such as
    - \* 30, 40a, 50a (not shown) of the other structural half of seat-cushion frame 3.3a,
    - \* 40, 50 of the other structural half of seat backrest frame 3.4a,
    - \* 30M, 40M, 50M, 65M (not shown) fastened to the cross members 3.41, 3.42 of seat backrest frame 3.4a facing each other,

30N, 40N, 50N, 65N (not shown) fastened to the cross members 3.31, 3.33 (not shown) of seat-cushion frame 3.3a facing each other.

Because the passenger was subjected to a succession of injury-irrelevant threshold values „ $\Delta F_i$ ”, where  $i = 1$  to  $n$ , during the accident and restrained by the seat belt, tensile strength of which about 24,000 N is substantially higher than „ $\Delta F_i$ ”, he needs only to depress the master release button 84, detaching all latch plates from buckle assemblies, and egresses, unscathed, from the vehicle, train or aeroplane (Figs. 1 and 14).

An energy-absorbing device, comprising a number of sets of energy absorbers, having different threshold values, is connected to the holder and to the latch plates of the seat belt in plug-in connection with the buckle assemblies of the seat backrest and/or -cushion.

- In another embodiment a sound-proofing material 83, having arbitrary friction coefficient  $\mu_0$ , different or progressive friction coefficient, is attached to the contact surface of retaining element and/or clamping element for the purpose of dampening vibration and performing work of friction. Furthermore, it is possible to coat the retaining elements and corresponding clamping elements, thus eliminating any noise.
- In the event of submerging and/or rollover the energy is dissipated by sets of energy absorbers, which are arranged in the seat-cushion frame and are tautly, less tautly and/or loosely connected to the buckle assembly.
- A single seat can be equipped with holder for persons (adults and/or children) of different ages related to weight groups, which depend on the appropriate sets of energy absorbers. The sets of energy absorbers and/or energy absorbers have different threshold values. Owing to these features the survival chance is enhanced for children and the seat occupancy is optimized in train, bus or aeroplane.

## 25 BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

Fig. 1 is a side view a rotatable shoulder holder 10e, equipped with energy absorbers 10.3, 30 rotated by the 2nd embodiment of a rotatable device 28a from the resting position P to the operative position  $P_1$ .

Fig. 2 is a perspective view of a restrained dummy, thrown forward in an offset crash test [1].

Fig. 3 is a perspective view of the 1st embodiment of a half of a shoulder- and neck holder 10 equipped with a set of energy absorbers 10.3, 10.5 and latch plate 10.1.

Fig. 4 is a schematic, perspective view of the 2nd embodiment of a shoulder- and neck holder 10a equipped with a wider chin-supporting neck collar 10.4a, energy absorbers 10.3a, 10.5a and latch plates 10.1f.

Fig. 5 is a schematic view of the 3rd embodiment of a half of a shoulder- and neck holder 10b equipped with the energy absorbers 10.3, 10.5, 10.9.

Fig. 6 is a schematic view of the 4th embodiment of a shoulder- and neck holder 10c equipped with energy absorbers.

Fig. 7 is a schematic view of the 5th embodiment of a half of a shoulder- and neck holder 10f, equipped with a latch plate 10.1f in plug-in connection with a buckle assembly 4b.

Fig. 8 is a perspective view of the 6th embodiment of a half of a rotatable shoulder holder 10d, rotated by the 1st embodiment of a rotatable device 28 from the resting position P to the operative position  $P_1$ .

Fig. 9 illustrates a total load „ $F_n$ ”, absorbed by the restraint system in co-operation with an energy-absorbing, vibration-dampening device, in the event of a real-world accident.

Fig. 10 is a schematic, perspective view of the 1st embodiment of a set of energy absorbers 30, 40e, 40f.

Fig. 11 is a schematic, perspective view of the 2nd embodiment of a set of energy absorbers 40, 40e, 40f.

5 Fig. 11a is a partially enlarged perspective view of a clamping element with sites of predetermined fracture „s” and both heads of a stop pin to block the clamping element.

Fig. 12 is a schematic, perspective view of the 3rd embodiment of a set of energy absorbers 50, 40e, 40f.

10 Fig. 13a is a schematic, perspective view of the 1st embodiment of a buckle assembly 4a comprising a guide piece 4.7a, release cable 4.2, tie band 1.1a and coupling member 1.2a.

Fig. 13b is a schematic, perspective view of the 2nd embodiment of a buckle assembly 4b comprising a guide piece 4.7b, an electrical motor 4.2b, a tie band 1.1b and coupling member 1.2b.

15 Fig. 13c is a cross-sectional view of the 3rd embodiment of a buckle assembly 4c comprising two tie bands 1.5, 1.6 along the line II-II of Fig. 13d.

Fig. 13d is a cross-sectional view of buckle assembly 4.8c, adjustable along the width of the back rest, having two holes to loosely guide two tie bands 1.5, 1.6.

20 Fig. 14 is a front view of safety seats 85a to 85e, 86, into which the seat belts 1a to 1e, sets of energy absorbers, shoulder holders 10, 10a, 10b, 10d, 10e and seats 3a to 3e are integrated, for passengers with different weights and body proportions.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

25 The advantages of the preferred embodiments, above-mentioned in the Chap. "Summary of the advantages...", are outlined hereinafter with regard to the functions and features thereof.

The method of the present invention in co-operation with a seat belt capitalizes on the premise that the total energy (magnitude of energy) is subdivided (Fig. 9), at the best, into a number of subenergies which are released in excess of the respective injury-irrelevant values, 30 pursuant to the energy-absorbing method, above-mentioned. This will be apparent by formulating all forces (Fig. 1), imposed on the torso 95.2 and head 95.1 of the passenger, in the event of a real-world accident where the torso, both shoulders and neck of a passenger are restrained by the shoulder- and neck holder and three-point or multi-point seat belt and the energy of two masses of the torso and head are absorbed by the energy-absorbers thereof.

35 The features are applicable for any motor vehicle, provided with arbitrary post sections (pillars), train or aeroplane.

In the 1st to 7th embodiment the shoulder- and/or neck holder 10, 10a to 10f, shown in Figs. 1, 3 to 8, comprises

40 – one- or two-piece caps 10.2, 10.2a to 10.2f with the shoulder-shaped energy absorbers 10.3, 10.3a and/or

– one- or two-piece caps 10.4, 10.4a to 10.4c, 10.4f with the neck-shaped energy absorber 10.5, 10.5a, 10.5c.

45 Two-piece caps of the shoulder holder have an advantage over a one-piece cap of the shoulder holder that it can be put into use for a passenger with two different shoulders. The problem of the one-piece cap of the shoulder holder can only be resolved by the use of two different shoulder energy absorbers.

The cap of shoulder- and neck holder 10, 10b (Figs. 3 and 5) is built by inserting a pair of neck-caps 10.4, 10.4b into a pair of shoulder-caps 10.2, 10.2b. This feature makes the design of the neck caps, insertably attachable thereto as well as detachable therefrom, possible.

Thanks to such design the passenger can decide for the use of the neck caps. If he or she is born with a weak neck muscle, the pair of neck-caps must be insertably attached thereto. On a hot day the neck caps can be removed therefrom. However, for children and persons, having very weak neck muscle, in particular when suffering from cervical trauma, the neck-shaped cap 10.4a of holder 10a is recommended. Its wider chin-supporting energy absorber 10.5a (Fig. 4) improves the properties of bracing the head and substantially absorbing energy during the forward motion of the passenger.

To restrain the shoulders and neck of a passenger, the one-piece holder 10a, in closed form and using a connecting cap 10.11, has the greatest stiffness, however by removing that connecting cap the holder 10c in open form does not block out air flow. This controversy is resolved by the stiff rotatable device 28, 28a of rotatable holder 10d, 10e in the different embodiments.

The latch plate 10.1 is pivotally attached to the flange 10.12 of shoulder- and neck holder 10 by pin 10.6 or by bolt 10.6a and nut 10.6b. The adjustment to the shoulder shape is done by rotating the bolt 10.7 in threaded hole of flange 10.12. Finally, that bolt is secured by nut 10.8. Time is greatly consumed for the removal of the belt from the closed apertures of cap 10.2 and the latch plate 10.1, to loosely guide the belt portion 1.1, in order to store the holder. Thanks to the open aperture 10.14 of cap 10.2b, 10.2c, 10.2f and open aperture of latch plate 10.1b, the belt, when strapped over the holder, can be loosely locked, guided by quick-release pin 10.10 and released by withdrawal of quick-release pin.

In the 5th embodiment ref. to Fig. 7 the latch plate 10.1f is secured to the flange 10.12f by pin 10.6, bolt 10.6a and nut 10.6b. By rotation of bolt 10.6a in the threaded hole of flange 10.12f, the cap 10.2f can be moved along the width of the seat backrest.

In the 1st or 2nd embodiment ref. to Figs. 1 and 8 each of the pair of casings 29, 29a, form-locking connected to each other, of rotatable device 28, 28a of holder 10d, 10e consists of two outer tubes

- 30 - 28.1, 28.2, force-locking connected with the coupling wall 28.3, and an L-shaped plate 28.4, or
- 41e, 41f, force-locking connected with the coupling wall 28.3, and an L-shaped, partly laterally closed and partly laterally open plate 28.4a.

The end of each rotatable lever 28.5, 28.5a is loosely guided between plate 28.4, 28.4a and coupling wall 28.3. Both rotatable levers are connected to each other by shaft 28.7. The cap 10.2d, 10.2e and release cam 28.6, 28.6a are fastened to the other end of each rotatable lever. In resting position each cap is located in the seat backrest or on its upper portion, if necessary, underneath the head rest 3.6a. If a supporting tube 3.61 is available, the cap, recessed about that supporting tube, must be reinforced by reinforcing plate 10.13.

40 Because the outer tubes 28.1, 28.2 or 41e, 41f are guided by inner tubes 71, 72 of seat backrest frame 3.4d, 3.4e, the height of the casings is adjusted in the direction of arrow „U“ (Figs. 1, 8) by manual operation or by a drive apparatus 80 e.g. hydraulic-piston cylinder unit, electrical motor (not drawn), similar to 4.2b in Fig. 13b.

45 The drive apparatus 80 can be activated by a switch, release button, controller, sensor or an accelerator pedal in reference to one of the Claims 7 to 10. Upon e.g. tipping the switch or release button the drive apparatus moves the holder 10d, 10e back to the resting position.

For the convenience of the passenger stepping out of the vehicle or in cases of emergency all latch plates of the seat belt are disengaged and the drive apparatus moves the holder 10d, 10e back to the resting position when depressing the master release button 84 of lap buckle assembly 9.1 (Fig. 14).

5 Due to the rotation of both rotatable levers 28.5, 28.5a, operated manually or by drive apparatus 80, both release cams 28.6, 28.6a force the rotation of the lock pawls 28.8, 28.8a, pre-loaded (biased) by springs 28.10, 28.10a, thereby permitting the locking pins 28.12, pre-loaded by springs 28.13, and loosely guided in guide tubes 28.11, to move into the holes 28.14 and block the rotatable levers

10 – 28.5 in both directions or  
– 28.5a in one direction.

When blocked, the loads in the event of rollover, yawing and/or turbulence-related vibration are reduced by the deformable holder 10d, 10e equipped with energy absorbers 10.3. The position of each guide tube 28.11 at the coupling wall 28.3 is denoted by the hole 28.14.

15 From the operative position P<sub>1</sub> to the resting position P both rotatable levers 28.5, 28.5a snap into the stop pieces 28.9, 28.9a and are retained thereby.

The belt portion 1.1, 1.2 is loosely guided by U-shaped plate 10.15, similar to 10.14, of cap 10.2e and, if necessary, loosely locked by quick-release pin 10.10 (Fig. 5).

20 In another energy-absorbing embodiment, the long outer tubes 41e, 41f, serving as retaining elements and girders, are parts of seat backrest frame 3.4d, 3.4e and energy absorbers 40e, 40f having clamping elements 42e, 42f, which are tightly, less tightly and/or loosely connected to the pair of rotatable levers 28.5a via the stop pieces 28.9a, serving as deflectors, by wires 47e, 47f in order to determine the onset of energy-absorption. Due to the forward motion of the dotted-line torso 95.2 and head 95.1 each dotted-line rotatable lever 28.5a with

25 cap 10.2e is rotated to the position P<sub>2</sub> through the opening of L-shaped, partly laterally-closed and partly laterally-open plate 28.4a, during which the work of deformation and friction is achieved by the deflection of the dotted-line clamping elements 42e, 42f along the respective retaining elements 41e, 41f. The stored energy is released in excess of the yield strength and/or of the threshold values. Additional clamping elements 32, 32.1 to 32.n, 42, 42.1 to

30 42.n, 52, 52.1 to 52.n can be arbitrarily arranged or be series-connected to clamping element 42e, 42f to absorb great energy and dampen strong vibrations.

In the 1st embodiment the set of vibration-dampening energy absorbers 30, 40e, 40f (Fig. 10) comprises a retaining element 31, control-wire 37, control-clamping element 32 and complementary clamping elements 32.1 to 32.n (not drawn). After projecting through or into the cylinder-shaped edges 37c1 of control-clamping element 32, both end portions of complementary wire 37a1 of control-wire 37 are secured by clamping two brackets 37b1 or both cylinder-shaped ends 37c1 therewith. The inner diameter „d<sub>i</sub>” of retaining element 31, 41 is a little larger than the outer diameter „d<sub>o</sub>” of inner tubes 71, 72.

In the 2nd embodiment ref. to Figs. 11, 11a the set of vibration-dampening energy absorbers 40, 40e, 40f comprises a retaining element 41, control-wire 47, control-clamping element 42 and complementary clamping elements 42.1 to 42.n. Owing to taut, less taut and/or loose connection of complementary wires 47.1, ..., 47.n with the clamping elements 42, 42.1, ..., 42.n, if necessary by occupying another pair of adjusting holes „L<sub>1</sub> to L<sub>c</sub>”, the onset of each clamping element, biased, is determinable. Owing to arbitrary connection of

45 wires with arbitrary clamping elements the fracture of the clamping elements can be predetermined in an arbitrary succession. Determinable, too, is the fracture of each clamping element to absorb energy, e.g. by reaming (bulging) the complementary clamping element 42.1, ..., 42.n in contact with both heads of stop pin or bolt 46.1, ..., 46.n with both sides of

wedge-shaped stop element 41.3 or by fracture in excess of the yield strength when increasingly loaded.

In the 3rd embodiment ref. to Fig. 12 the set of vibration-dampening energy absorbers 50, 40e, 40f comprises a cone-shaped retaining element 51, control-wire 57, control-clamping element 52 and clamping elements 52.1, .., 52.n and 53.1, .., 53.n (not-shown). Both ends of complementary wire 57a1 of control-wire 57 are secured to a control-clamping element 52 by rivets 57b1.

The load-deflection area is achieved progressively or arbitrarily by the expansion of cone-shaped clamping element 52, .., 52.n, 53, ..., 53.n along

- 10 – the cone-shaped retaining element 51 and/or
- the longitudinal rib 51.1 whose thickness longitudinally increases.

The space in the seat backrest and -cushion is exploited to accommodate a number of sets of energy absorbers, having different threshold values for baby, child, adult, old woman and man, which are connected to the shoulder- and/or neck holder and buckle assemblies, whereto the latch plates of, preferably, the multi-point, one-piece seat belt of the seat 3a to 3d, shown in Fig. 14, are plug-in connected. In a real-world accident this energy-absorbing, vibration-dampening device, operating without sensors, but with the multi-point, one-piece seat belt gradually absorbs great energy below the injury-related values and dampens vibrations. In comparison with the energy-absorbing management device, monitored by the three-sensor mechanisms, aforementioned and proposed by US 5,544,918, the operation is more reliable, the injury severity is substantially lower, the manufacturing costs are far lower and there is neither recall programs nor court-cases.

In the 1st and 2nd embodiment of the buckle assembly 4a, 4b (Figs. 13a and 13b), to receive latch plate 2, 11, 25, the one-piece guide piece 4.7a, 4.7b is provided with a recess 4.5a or longitudinal groove 4.5b to loosely guide tie band 1.1a, 1.1b, having coupling member 1.2a, 1.2b, to which the wires of sets of energy absorbers 30, 40, 50 are tautly, less tautly and/or loosely connected.

After the insertion, in the direction of double arrow, of a pair of engaging parts 4.10a, 4.10b of guide piece 4.7a, 4.7b in the apertures of the housing 4.8a, 4.8b of buckle assembly 4a, 4b the clamping parts 4.12 snap into the clamping holes 4.13.

When the latch plate is pulled under the load of „ $\Delta F_1$  - 500 N”, less than the starting threshold value „ $\Delta F_1$ ”, the buckle assembly, clamping element/s and energy absorber/s move about the deflection „ $T_F$ ” (not drawn). In the state of non-deformation the housing 4.8a, 4.8b with/without clamping parts 4.12 must be pulled back into the engaging parts 4.10a, 4.10b.

35 This is possible, when „ $T_1$ ” is at least as long as „ $T_s + T_F$ ”. Experiment can clarify, whether the clamping parts and clamping holes are needed. However, the clamping assemblies have the advantage of exactly positioning the buckle assembly in the seat backrest or -cushion.

Due to the restriction for the depth „ $T$ ” of seat backrest or -cushion (Fig. 14) the length „ $T_L$ ” of engaging parts 4.10a, 4.10b is restricted too, hence, the following countermeasures are required:

- 40 – When the buckle assembly under load of great impact energy moves along the engaging parts, the tie band 1.1a, 1.1b must be guided by the guide piece 4.7a, 4.7b, fastened to the seat frame;
- In order to exploit the depth „ $T$ ”, the length „ $T_Z$ ” of latch plate and/or the length „ $T_L$ ” of engaging parts 4.10a, 4.10b is/are increased;
- By not using guide piece the wires of sets of energy absorbers can tautly, less tautly and/or loosely be connected to couple member 1.2a, 1.2b or an end of the seat belt; and/or

- Owing to biasing at least one control-clamping element 32, 42, 52 at „ $\Delta F_1$  - 500 N“ the housing can only move in excess thereof for the purpose of undampened energy-absorption.

5 In the 3rd embodiment of the buckle assembly 4c (Fig. 13c), to receive latch plate 2, 9, 11, 25, the housing 4.8c, that can be moved along a pair of tube 27.3 of the frame of seat backrest or seat cushion and latched thereon, are provided with two holes 4.5c to loosely guide tie bands 1.5, 1.6, having couple members 1.2a, 1.2b. A wire is projected through the hole 2.3 of buckle assembly 4c. Both end portions, serving as tie bands 1.5, 1.6, are secured by a mutual bracket 1.7. The engaging part 4.10c of buckle assembly 4c is in pig-tail- or 10 form-locking connection to an aperture of housing 4.8c. Large height- and width-adjustment can result in slackness and inaccuracy when biasing the wires. Such shortcoming is resolved by directly attaching the sets of energy absorbers to the parts (not drawn) of the height- and width-adjustable mechanism.

15 The buckle assembly 4a, 4b, 4c is suited for buckle assembly 4, 7, 8, 8a, 9.1, 18a, 18b, 19a, 19b (Fig. 14). For the convenience of the passenger egressing from the vehicle or in cases of emergency all latch plates of the seat belt and holder 10, 10a to 10c, 10f are disengaged when depressing the master release button 84 of lap buckle assembly 9.1 (Fig. 14).

20 Thanks to plug-in connection of at least one anti-submarining latch plate 11, 25, movable along the lap belt portion 1.3, with an anti-submarining buckle assembly 7, 8, 8a of the seat cushion (Fig. 14), provided with sets of energy absorbers, the energy, imposed on both thighs, in the event of submaring and/or rollover is absorbed and released by fracture of the sites of predetermined fracture. To properly restrain both thighs of a child, sitting on the seat 3a, three movable anti-submarining latch plates 11, 25 are in plug-in connection with the respective anti-submarining buckle assemblies 7, 8a. So a safety child-seat 85a, 85b is created 25 by integration the seat belt, energy absorbers and holder into the seat itself.

Another application results from direct conversion of a child-seat 85a into

- a baby-cot 86 by flipping the seat backrest 3.2a into a resting position or
- a safety adult-seat 85a by disconnecting the movable latch plates 25 from the anti-submarining buckle assemblies 8a, repositioning the seat backrest to an adult-seating position and mounting the holder 10a back into the cutaway of the seat cushion.

30 Thanks to the multi-purpose of energy-absorbing, vibration-dampening safety seat a high rate of seat occupancy in an aeroplane can be achieved and there is no need for purchasing child-seats and baby-cots, administrating, storing and transporting them anymore.

35 Notably, any passenger of any age, body proportion and weight is protected from severe/fatal injury by the energy-absorbing device incorporated with the multi-point seat belt and insertable or rotatable attachment of the shoulder- and/or neck holder 10, 10a to 10f to the seat backrest frame.

40 Lack of functional tests to determine the permeability, stiffness and design of the caps and properties of energy-absorption it is necessary to design a number of holders to restrain the upper part of body 95 of a passenger (dummy), restrained, preferably, by the multi-point seat belt, in order to determine the cheapest design characterized by the best mode to reduce all acceleration-dependant forces, dampen vibrations and avoid whiplash in crash tests.

45 Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.